MEASURING THE EFFECT OF ALTERNATING IN-CLASS WITH ONLINE LECTURE ON
STUDENT LEARNING IN COLLEGE CLASSROOMS

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Personalized instruction has long been a goal of behavior analysis in the education of typically developing populations, one important element of which is the delivery of lectures in new formats. This study tested feasibility of online lecture delivery by comparing online and in-class delivery of lectures using an adapted alternating treatments design. Each week, the lecture component of a unit of an introductory behavior analysis course was presented either online or in-class, alternating week to week. The alternation was counterbalanced between two sections, where one section saw the lecture for a given unit online while the other did it in-class, allowing for comparison between lectures of a given unit as well as across units within a section. First attempt quiz scores were measured. No significant difference in the trend of quiz scores between conditions was detected, averaging 73.1% (range, 50.4% to 83.4%) for online and 72.8% (range, 54.8 to 84%) for in-class conditions. This suggests that online lectures are a feasible alternative lecture delivery in this introductory behavior analysis course. This experimental methodology may also be used to test other instructional techniques as well. The ability to place lectures online, opens the door to further, more refined, experimentation with modern instructional methods such as the “flipped classroom.”
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By

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CHAPTER 1
INTRODUCTION

Over the past half-century, behavior analysts have developed many educational technologies that have achieved greater success than some traditional educational approaches (Holland, 1968; Walker & Rehfeldt, 2012). Thomas Gilbert developed “Mathetics”, the first attempt at a technology of instruction based on the principles of behavior in 1962. Subsequently, B.F. Skinner (1968) developed a teaching technology called “programmed instruction.” Simultaneously, Fred Keller (1968) also developed a comprehensive self-paced, mastery-based system of instruction he called a “personalized system of instruction” (PSI). These early applications of the principles of behavior analysis to education spurred the efforts of many others to improve the quality of education at many levels.

The application of behavior analytic principles to the classroom has evolved alongside technological advances. Skinner (1961) promoted the use of machines to expose students to curriculum. His “teaching machines” could require a certain response from the student before moving forward to the next task (mastery based learning) and the students could progress at their own pace. This kind of personalized attention is somewhat difficult in a traditional instructional situation in which instructors must cater to the needs of large groups of students. However, as computer technology became more advanced, more instructional technologies became available (Layng, Twyman & Stikeleather, 2003; Pear & Crone-Todd, 1999).

Today, some college courses are presented entirely online (Mackness, Mak, & Williams, 2010) or online materials are used to supplement traditional in-class instructional formats (Oh & Park, 2009). The latter is often referred to as “blended” instruction. Many university
instructors are using and experimenting with these technologies (Chao, Brett, Wiecha, Norton & Levine, 2012; Jenkins, Goel, & Morrel, 2008). Kulik and Kulik (1987; 1991) conducted the first widely cited meta-analyses on the effectiveness of computers in instruction. They found that computer aided instruction, of all types, tended to increase student scores slightly relative to baselines and controls. Timmerman and Kruepke (2006) performed another, more recent, meta-analysis of the effect of computer-aided instruction of all types on student performance in the class. They found that, on average, computer aided instruction slightly enhanced student performance relative to controls and baselines. However, computer aided instruction was broadly defined. For example, it could include the use of multi-media presentation tools such as PowerPoint into lectures, the use of a CD-ROM instead of a book for a given reading, or some combination of the previous plus computer-based quizzes. In this study, we sought to more clearly define which aspects the computer-aided aspects of the course.

Further, research within behavior analysis and higher education has addressed some techniques of instruction and assessment (See Table 1.1). The pursuit of behavior analytical solutions to problems within higher education has resulted in recommendations for improving the effectiveness of instruction, e.g. guided notes (Lazarus, 2003 Neef, McCord, & Ferreri, 2006), increasing teaching opportunities, e.g. active student responding (Kellum, Carr, & Dozier, 2001; Wesson, 1988), designing structured learning activities, e.g. Say All Fast Minute Each Day Shuffled [SAFMEDS] (Cihon, Sturtz, & Eshlemann, 2012; Eshlemann, 1985) and interteaching (Boyce & Hineline, 2002; Saville, Zinn, Neef, VanNorman, & Ferreri, 2006).

Many of these researchers (Neef et al., 2006; Kellum et al., 2001; Cihon et al., 2012), have employed the use of single-subject research methodology and chose specifically an
alternating treatments design in which one or more teaching strategies are introduced in a course and tested against what is already being implemented or another variation of the new teaching strategy. This design can be useful if researchers are interested in evaluating the benefits of one instructional strategy over another in a way that all students experience both interventions in an alternating fashion (Barlow & Hayes, 1979).

Table 1.1

<table>
<thead>
<tr>
<th>Technique</th>
<th>Date</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guided Notes</td>
<td>2003</td>
<td>Lazurus, 2003 Neef, McCord, &amp; Ferreri, 2006</td>
<td>Power point slides with blanks left to be filled in with the lecture. Used to give students time to engage the lecture while forcing them to respond in order to have notes.</td>
</tr>
<tr>
<td>Active Student Responding</td>
<td>1988</td>
<td>Wesson, 1988 Kellum, Carr, &amp; Dozier, 2001</td>
<td>Use of response cards to encourage all students to respond to questions in lecture.</td>
</tr>
<tr>
<td>SAFM Edwards</td>
<td>1985</td>
<td>Eshleman, 1985</td>
<td>Like flashcards but requires the student to say all words extremely fast, in order to prepare for timings in precision teaching.</td>
</tr>
<tr>
<td>Interteaching</td>
<td>2002</td>
<td>Boyce &amp; Hineline, 2002 Savile, Zinn, Neef, Van Norman, &amp; Ferreri, 2006</td>
<td>It divides students into groups to address content they've already read about and expects them to present what they've discussed. Then it requires students to assign points to one another.</td>
</tr>
</tbody>
</table>

Research on the effectiveness of online lecture presentation, however, has yielded little attention from the behavior analytic community and a single-subject evaluation of the
comparative effectiveness of online or in-class lecture presentations can offer the benefit of analyzing individual student data to determine whether individual students respond differently to lecture presentation formats. The purpose of this study was to evaluate the effectiveness of online lectures in two sections of an “Introduction to Behavior Analysis” undergraduate course. The specific research questions addressed were: 1) Do individual students respond differentially to online compared to in-class lecture presentations as measured by weekly quiz scores? And 2.) What are the effects of online compared to in-class lecture presentation on undergraduate students’ mean weekly quiz scores?
CHAPTER 2

METHODS

2.1 Participants and Setting

Students enrolled in two sections of an Introduction to Behavior Analysis class at the University of North Texas (UNT) were recruited for this study. The Introduction to Behavior Analysis class is the first course in a series of undergraduate courses in Applied Behavior Analysis. The goals of this course are to familiarize students with basic introductory concepts, to develop their ability to discuss those concepts with group work and writing, and to apply learned concepts in a behavior change project. This course was part of the University’s NextGen course redesign program. The NextGen course redesign program was designed to assist instructors to use technology to improve the efficiency of instruction, with a particular focus on increasing student engagement during classroom time. Additionally, the program encourages instructors to create general and specific learning outcomes that link to course assessments so that instructional effectiveness can be measured.

Fifty-eight of 73 students enrolled in the course gave consent to participate in the present study. Twenty-eight participants were male and 30 participants were female. The two course sections took place on Mondays, Wednesdays, and Fridays. Section 1 met from 9:00 am to 9:50 am (25 participants) and Section 2 met from 10:00 am to 10:50 am (33 participants). Participants ranged in age from 18 to 37 and were not excluded based on race, ethnicity, or gender; however, students under the age of 18 were not part of the recruitment sample (n = 1).
2.2 Materials

2.2.1 Text, Homework, and Quizzes

Course units were chosen from *Principles of Everyday Behavior Analysis, 4th edition* by L. Keith Miller. Homework questions were adapted directly from questions in the text whenever possible. Quiz questions were adopted from homework questions. Key concepts were taken directly from the text and taught as specific learning outcomes. Students completed homework outside of class times, and quizzes were conducted each Friday in class. Each student was given two attempts at each quiz. Each attempt was taken from a separate test bank, which meant that the second quiz was composed of different questions than the first quiz. After attempting the first quiz students were allowed to receive tutoring on questions they missed before they took their second quiz attempt.

2.2.2 PowerPoint

The instructor presented lectures with a standard PowerPoint presentation. The same instructor presented these lectures for both sections. The speech portion of the lecture differed slightly from the online condition as the instructor worked off of notes not a script. A sample of the PowerPoint slides used during the study is presented in Figure 2.1.

2.2.3 Adobe Captivate

Lectures were created in Adobe Captivate and presented within the browser in Blackboard Vista. Online lectures were created directly from the PowerPoint presentations used in the lecture condition. The audio portion was recorded by the instructor who taught in
the lecture condition. Lectures were available when the in-class lecture would have normally started and remained available until 8 am Wednesday for both sections. The online lecture was available for 49 hours for Section 1 and 48 hours for Section 2 each week it was made available.

Figure 2.1. Sample lecture slides. These slides, from the unit 2 in-class lecture, show a cross section of the sorts of activities and diagrams presented in both conditions.

2.2.4 Blackboard Vista

The instructor posted class materials in Blackboard Vista throughout the course of study. Each student took online homework assessments, downloaded guided notes for in-class or online lectures, watched online lectures, and took their quizzes in-class on Blackboard Vista.
2.3 Dependent Measures and Data Analysis

First attempt quiz scores were the dependent variable. Individual scores were tracked on blackboard and transferred into Microsoft Excel for each participant. Those scores that may have shown an effect are discussed below in the results section. In addition, mean first attempt quiz scores were calculated for each section by condition. Sample quiz questions are presented in Table 2.1.

Table 2.1

Sample of Quiz Questions

<table>
<thead>
<tr>
<th>Unit</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Behavior that is not affected by consequences is called [respondent] behavior.</td>
</tr>
<tr>
<td>6</td>
<td>The procedure of extinction has two critical components. The first is that the [reinforcer] is stopped. The second is that the rate of the behavior needs to [decrease].</td>
</tr>
<tr>
<td>12</td>
<td>Positive punishment occurs when an event is added contingent on the occurrence of a behavior and the rate of the behavior [decreases].</td>
</tr>
</tbody>
</table>

2.4 Independent Variables

The independent variable was the lecture presentation format: in-class or online. In one condition, the lecture was presented in-class on Monday morning. In the other condition, the lecture was presented online so that the students could watch it at their convenience. The online lecture, made in Adobe Captivate, was available through Blackboard Vista from the normal lecture times of 9 a.m. or 10 a.m. Monday morning depending on the section, to 8 a.m. Wednesday. The in-class condition differed from the online condition in a few ways. In the in-class condition, students had immediate access to the instructor and could ask questions in real time. In the online condition, students could revisit the lecture at their own pace and stop and
start it as they wished. They were also expected to access the online lecture on their own time, rather than being required to go to class for a lecture. When students had access to online lectures, they did not have an in-class lecture, and when they had a lecture in-class, they did not have access to an online lecture.

2.5 Experimental Design

An adapted alternating treatments design (Sindelar, Rosenberg, & Wilson, 1985), counterbalanced across course sections was used to evaluate experimental control. One of the two conditions was presented every other week for each section. The students who were enrolled in one section received one lecture format (for example, online lecture), while the students enrolled in the other section received the other lecture format (i.e., in-class lecture). This sequence continued, alternating each week for the duration of the study (see Table 2.2).

Table 2.2

<table>
<thead>
<tr>
<th>Unit</th>
<th>0.001</th>
<th>0.002</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Online</td>
<td>In-class</td>
</tr>
<tr>
<td>2</td>
<td>In-class</td>
<td>Online</td>
</tr>
<tr>
<td>3</td>
<td>Online</td>
<td>In-class</td>
</tr>
<tr>
<td>4</td>
<td>In-class</td>
<td>Online</td>
</tr>
<tr>
<td>5</td>
<td>Online</td>
<td>In-class</td>
</tr>
<tr>
<td>6</td>
<td>In-class</td>
<td>Online</td>
</tr>
<tr>
<td>7</td>
<td>Excluded*</td>
<td>Excluded*</td>
</tr>
<tr>
<td>8</td>
<td>Online</td>
<td>In-class</td>
</tr>
<tr>
<td>9</td>
<td>In-class</td>
<td>Online</td>
</tr>
<tr>
<td>10</td>
<td>Online</td>
<td>In-class</td>
</tr>
</tbody>
</table>

*. Units 7 was never part of the study.
2.6 Procedure

During the first week of the course, the instructor made introductions, reviewed the syllabus and expectations, and obtained informed consent. In the second week, the instructor initiated the alternation of experimental conditions. On Monday, the lecture from Unit 1 was presented online for Section one and in-class for Section two. Wednesday involved an in-class discussion for both sections. Quizzes were taken during the class meeting on Friday. This general pattern was repeated weekly and alternated accordingly with the exception of week seven, when the lectures were presented in-class and for which quiz attempts were not analyzed for this study. At the end of ten weeks, data collection ceased. Unit seven was not included in the study as it was a new unit and was taught in-class for both sections. Units eleven and twelve were not included in the study as the treatment integrity of the independent variable could not be confirmed due to a coding error.
CHAPTER 3

RESULTS

Figure 3.1 shows group mean first-attempt quiz scores for all units, summarized by experimental condition. First attempt quiz scores remained stable, averaging 73.1% (range, 50.4% to 83.4%) for online and 72.8% (range, 54.8 to 84%) for in-class conditions across both sections. Unit 8 mean quiz scores dropped to near 52.6% in both conditions (online range, 0% to 90%; in-class range, 20% to 80%).

![Average Quiz Scores - First Attempt](image)

*Figure 3.1. Mean first attempt quiz scores for both conditions.*

Most of the 58 participants ($n = 57$) showed no appreciable difference between conditions or had taken so few quizzes (fewer than 2 quizzes in each condition) that it would have been impossible to tell if there were differential effects. Of these participants, some ($N = 4$) showed a slight separation between conditions; however, the patterns corresponded to mean differences across units. All participants’ data were also analyzed by grade and section...
with no apparent differences emerging (for breakdown of number of students by grade and section see Table 3.1).

Table 3.1

**Grade Break Down**

<table>
<thead>
<tr>
<th>*</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>19</td>
<td>12</td>
</tr>
<tr>
<td>C</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>D</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>28</td>
</tr>
</tbody>
</table>

* N=58

Participant 1-4 was the only participant whose data appeared to show a clear separation between conditions for part of the experiment (Figure 3.2). His online quiz scores started low for unit 1 (35%), and stayed low for units 3 (35%), and 5 (35%), averaging 35% for the first six units. His scores increased for units 8 (70%) and 10 (100%), averaging 55% for the condition. The in-class scores also started low for unit 2 (50%) and showed an increasing trend for units 4 (60%), and 6 (80%), averaging 63% for the first six units. Then there was an increase for unit 9 (90%), averaging 70% for the condition.
Figure 3.2. These graphs show individual participant first attempt quiz scores between conditions.
CHAPTER 4

DISCUSSION

Providing college curriculum online may save money and provide instructors with room to try different instructional strategies in their course. The results of the current study suggest that with the exception of one student, there was little difference in the effectiveness of in-class compared to online lecture presentations. The present findings are consistent with much of the research (Bauer & Huynh, 1998; Chao et al., 2012; Clark et al., 1997; Faul et al., 2004; Jenkins et al., 2008) that has indicated little differentiation in the effectiveness of online and in-class lecture formats.

There are several possible reasons why the differences between average first attempt quiz scores were so small between conditions. One reason might be that lecture format is generally less important in terms of effect on student performance than unit difficulty or other instructional factors. Another reason might be that students didn't pay attention to a particular in-class lecture, or were distracted during an online lecture. It may even be that students did not attend in-class lectures, or did not watch online lectures in the first place.

Any time applied research takes place in the higher education classroom, the ability of the instructor to manipulate motivational variables concerning participation in the course and in the study should be considered. Naturally, the classroom poses challenges when evaluating the contingencies that might govern participation. For example, some students' individual data could not be successfully evaluated because there were too few data points to see trends in either condition. Perhaps these students skipped quizzes, or dropped out of the course entirely. The instructor could have enforced existing policies for course grade, but might not have been
able to otherwise encourage students to participate in the study, or for that matter, various aspects of the course. However, this may be less of an issue to experimenters than it is to instructors, as the classroom setting almost always provides many participants to study and draw conclusions from.

In the current course, students did not take quizzes immediately following lecture presentation. In-class discussions (ICDs) occurred on Wednesdays between the lecture (Mondays) and the quiz (Fridays). These discussions took place every Wednesday, across both conditions. While exposure to the ICD was uniform across conditions, it introduced an extraneous variable that could have affected first attempt quiz scores by adding opportunities for individualized instruction beyond the lecture. In order to obtain a cleaner analysis of the impact of lecture format on student learning, researchers might consider offering a short assessment of student learning immediately following the lecture.

Also, it may have been that students did not attend lecture classes or watch online lectures because attendance was not a mandatory part of their grade. We did not take regular attendance during lecture classes and did not track whether or not students accessed online lectures on Blackboard. Because we do not know if the students watched the lecture, we cannot be entirely sure of the impact of the two lecture formats on the dependent variable.

Fifty-seven out of fifty-eight students did not show an effect between conditions when individual data were examined. The adapted alternating-treatments designed allowed us to introduce each participant to both independent variable conditions, allowing us to see individual effects, or in this case make sure there were not any that differentiated from mean scores. Participant 1-4 showed a separation in the trends of his first-attempt quiz scores for the
first 6 units of the course. The upward trend of his in-class quiz scores was contrary to average trends. His consistently low scores in the online condition for the first 6 units suggests that he may have learned better in-class then online. It might also suggest, however, that he simply did not watch the online lectures. Not having tracked either attendance or access of online lectures, we cannot evaluate this further. Additionally, the fact that only one of fifty-eight students showed this effect further supports the conclusion that online lecture formats do not detrimentally affect most students’ performance. Nevertheless, future research should include measures to track attendance at in-class lectures and access to online lectures in order to better understand the effects of lectures on student performance in general.

An alternating treatments design (Barlow & Hayes, 1979) was especially helpful in evaluating the effect of these conditions on individual participants and has been useful to evaluate other instructional techniques in the college classroom (Neef et al., 2006; Kellum et al., 2001; Cihon et al., 2012). This is not to say, however, that this design would fit the needs of testing any instructional technique. Group designs or other single subject designs might work better in other situations. The adapted alternating- treatments design works best in situations where the instructional technique works as a stand-alone unit, such as instructional format. It might be particularly difficult in situations where the instructional technique is expected to have an aggregated effect, such as a new text or access to a semester long project. Such situations might be better served by an analysis that employs a group design or some single subject design that does not employ rapid alternation, such as a multiple baseline design (Hall, Cristler, Cranston, & Tucker, 1970). The utility of the adapted alternating treatments design is that each participant is exposed to all independent variables. When the conditions of an
independent variable might be reasonably alternated, this design may be a convenient and non-obtrusive way to test instructional techniques in the college classroom, especially when the size of a course or the time allotted to study may make conditions less than ideal for other experimental designs.

When using alternating treatments designs in the college classroom, it is especially important and difficult to track when a group of participants were exposed to what experimental condition. In this study, treatment integrity could not be verified for the last two units of the course because the experimenter did not use a reliable coding system and experimenters were forced to rely on memory and archived documents (e.g., course syllabi, gradebooks, and emails). While it is likely dependent measures might be taken out of a gradebook, and the contents of that gradebook will be accurate even years after the course has taken place, it may be difficult to assure treatment integrity later on if there is no secondary code in the gradebook for what condition was used at any given time. Researchers interested in pursuing this line of research should include a note in the course gradebook that can be used to identify which condition is implemented when. This entry could be either a separate note, or some coding convention designed to allow for the double checking of treatment integrity later on. It is also recommended that experimenters make a log of their procedures as an additional check.

When combined with secondary measures of treatment integrity, the adapted alternating treatments design can prove an otherwise convenient and efficient way to measure lecture format. This is especially important, as a discussion of lecture format may be confused by a broader discussion of the effects of computers in teaching in general. (Kulik & Kulik 1987;
The majority of studies (Timmerman & Kruepke, 2006) discussed that only compared in-class lectures to some online accessible version of a lecture and used some quantitative measure between conditions found little difference in lecture format overall. Our study would replicate those findings, while not replicating the view that “computer assisted instruction” provided a slight benefit in this instance. This makes sense, as the definition of “computer assisted instruction” is quite broad.

The question of online compared to in-class lecture delivery is important because many instructors are interested in trying it, but may be concerned about its effect on student performance and student learning. This study would suggest that lecture format had little differential effectiveness on student performance overall, but other courses may have different motivational factors at play. Some instructors may be interested in experimenting with a “Flipped Classroom” (Koller, 2011). In a flipped classroom, lectures are presented online, and work that is traditionally done at home is done in class where instructors can help students with it. This might be appealing to an instructor who finds it easy to record lectures but worries that students are having a hard time with practice work. Placing lectures online might also free up class time for more activities, group work, or working in the community, applying what students are learning. This might be particularly appealing to an instructor who worries that students are learning to recall terms but are not learning useful life skills. Finally, putting lectures online might free up an instructor to experiment with self-pacing if they wish. Self-paced, mastery based education has been shown to have some success in the past (Keller, 1968), but may be difficult to implement where instructors have used deadlines and the timing of lectures as motivational factors. If instructors should wish to experiment with “flipping,” more application,
or self-pacing, in an existing college course structure that is otherwise traditional, the first thing they would have to do is determine the effect that moving their lectures online would have on student performance.

Thus, this study may serve as a model for many others. The experimental methods employed here can be replicated quickly, inexpensively, and with little effort. This way, an instructor can learn if moving their lecture online will likely work for them. If a large and diverse group of instructors replicate these experimental methods, then there might be sufficient information to make the argument that, in general, online lectures are at least as effective as in-class lectures. For the present, we may make the argument that it works to move lectures online in our Introduction to Behavior Analysis course and perhaps in courses with a similar structure.
1 Introduction topics – Students will demonstrate a general understanding of introductory topics in BA

1.1 Demonstrate understanding of key terms and historical markers by

1.1.1 Defining key terms
1.1.2 Identifying examples of key terms in context
1.1.3 Discriminating between key terms

1.2 Develop fluent speaker repertoire concerning the topic

1.2.1 Demonstrate understanding of lecture concepts within a group discussion
1.2.2 Student participates in lecture (choral responses, asks questions)
1.2.3 Demonstrate understanding of concept to TA’s during quiz tutoring

2 Basic Concepts – Students will demonstrate an understanding of basic concepts in BA

2.1 Demonstrate understanding of key terms and historical markers by

2.1.1 Defining key terms
2.1.2 Identifying examples of key terms in context
2.1.3 Discriminating between key terms

2.2 Develop fluent speaker repertoire concerning the topic

2.2.1 Demonstrate understanding of lecture concepts within a group discussion
2.2.2 Student participates in lecture (choral responses, asks questions)
2.2.3 Demonstrate understanding of concept to TA's during quiz tutoring
2.2.4 Use Algorithm to identify parts of contingencies involving key concepts
REFERENCES


